Midas

MARGINAL LANDS, INDUSTRIAL CROPS AND INNOVATIVE BIO-BASED VALUE CHAINS

Deliverable D2.5 Report on irrigation system performance on dry areas of Med

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1 introduction

The limited availability of water in various regions has led to the construction of different types of water tanks for rainwater collection and storage, dating back to the earliest human settlements. Technologies have evolved for the construction and utilization of these tanks. The earliest water harvesting structures are believed to have been built 9,000 years ago in the Edom Mountains of southern Jordan to provide drinking water for people and animals (Prinz, 1996).

Global warming and climate change are threatening the effectiveness of agriculture in the Mediterranean area, which is globally recognized as a climate change hotspot. Increasing aridity and the occurrence of extreme rainfall events can have detrimental effects on agriculture, necessitating the enhancement of its resilience. One potential solution to this issue is the application of rainwater harvesting technology (RWH), particularly the Subsurface Water Retention System (SWRS). This system involves placing an impermeable membrane in the root zone to prevent water loss through deep percolation in sandy soils. Recent studies have highlighted the effectiveness of SWRS in increasing crop yields in arid and semi-arid climates. However, its application has been limited to laboratory scale due to the lack of efficient machinery for extensive implementation.

The objective of this experiment is to evaluate the SWRS system at a field scale. In a previous EU project, the CREA team developed the machine and studied the efficiency of the prototype from economic and mechanical perspectives, but it lacked real field implementation. The previous results were encouraging, and now, with several SWRS fields under different agricultural management, we can test the real application of this system using the CREA prototype.

1.1 History of the SWRS

The expanding aridity in North African countries and some Southern European countries, such as Italy, Greece, and Spain, is a major issue limiting agriculture and thus the adequate and reliable production of food. Additionally, global warming, a worldwide phenomenon that could cut the global economy by $23 trillion by 2050, is creating concern among academics and politicians, as the Mediterranean might be especially vulnerable to global change. In fact, in North African countries, precipitation events are expected to become rarer in the future but characterized by extreme rain events. During extreme events, most of the rainwater is not adsorbed by the soil. Given the importance of water, rainwater harvesting systems have been developed to valorise this resource that is lost. These systems often involve intercepting rainwater and collecting it in tanks, where it remains available for irrigating local fields. Other efforts have focused on constructing underground check dams, which, according to the literature, have helped reduce stormwater runoff, improve water management, and increase crop yields. However, the strategy of building more dams and irrigation canals to transport retained water to distant dry fields is difficult to implement. Accordingly, some researchers have begun investigating the possibility of retaining water near crop root zones. Technological options aimed at decelerating the deep percolation of water and nutrients by altering soil composition and structure have various merits and limitations. To address these challenges, CREA-IT has developed a prototype that could enhance all aspects related to increasing soil water retention.

USE OF IMPERMEABLE MEMBRANE

During the last two decades, several studies followed by applying impermeable. Elawady et al. (2003) reported an 18 % yield increase in spinach (Spinacia oleracea L.), whilst Awady et al. (2008) found an increase in tomato fruit yield (*Solanum lycopersicum* L.).

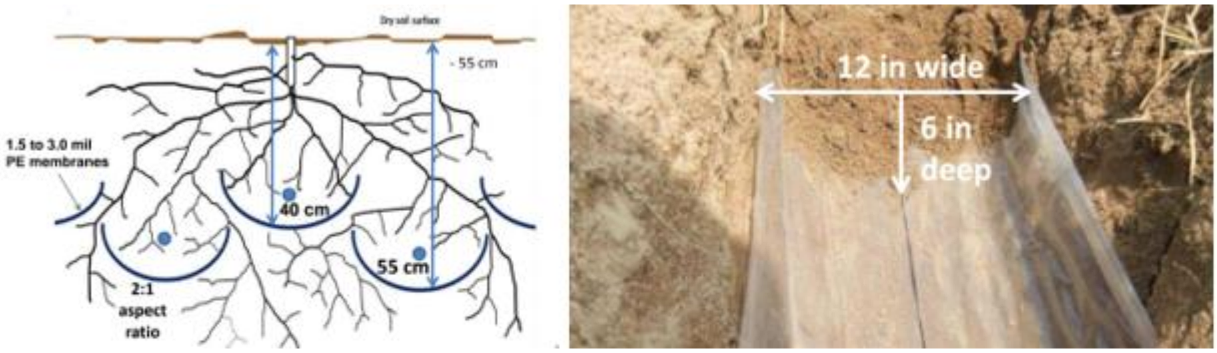


Figure 1 Starting idea of impermeable membrane SWRS.

Other studies performed in Iraq highlighted positive effects of impermeable membrane SWRSs on both yield and water use efficiency in the chili pepper (Capsicum annuum L.). Kavdir et al. (2014) investigated the use of impermeable membranes in irrigated sandy soils, finding an increase compared to normal conditions.

Figure 2 View of the growth difference

Nevertheless, the effective contribution of such knowledge to address vast problems like desertification and food production in arid and semi-arid areas of the planet cannot be proved until SWRSs are tested in large field experiments. To achieve the field implementation and considering the beneficial effects of SWRSs found in small scale experiments on vegetable production, the Michigan State University and RFW Bron (Woodstock, Canada) developed a SWRS prototype capable of installing a U-shaped impermeable membrane 15–45 cm deep in the soil. To achieve the field implementation and considering the beneficial effects of SWRSs found in small scale experiments on vegetable production, the Michigan State University and RFW Bron (Woodstock, Canada) developed a SWRS prototype capable of installing a U-shaped impermeable membrane 15–45 cm deep in the soil. From this starting idea, CREA-IT developed a new prototype for the field implementation of this system.

1.2 CREA-IT Prototype

The prototype was developed starting from a double-wheel central excavation ditcher, with modifications to this type of machinery, which is typically used for excavating ditches in agricultural fields.

The digging capacity of the machinery is provided by the rotary wheels, which are mounted laterally to the main framework at a 23° angle. These wheels are driven by the tractor's PTO set at 1000 rpm, requiring about 100 kW of power, and the machinery weighs approximately 2000 kg. The depth of the ditch is adjusted using the tractor's 3-point hitch, with a maximum reachable depth of 1.00 m. To set up a SWRS, the excavated soil must be collected and returned to the ground just above the impermeable membrane film to allow for plant cultivation. To accomplish this, a pair of conveyors (one per wheel) were installed above the machinery. The kinetic energy from the spinning wheels drives the dug soil particles backward, depositing them right above the film. Additionally, the shape of the knives on the wheels was modified to have a higher curvature, allowing them to retain soil longer and direct it to the conveyors. Behind the wheels, two arms carry the impermeable roll, which unrolls as the machinery moves forward in the field. Finally, a V-shaped metal structure is positioned just after the roll to ensure the proper unrolling of the membrane. A vision of the prototype is provided in the Figure 3.

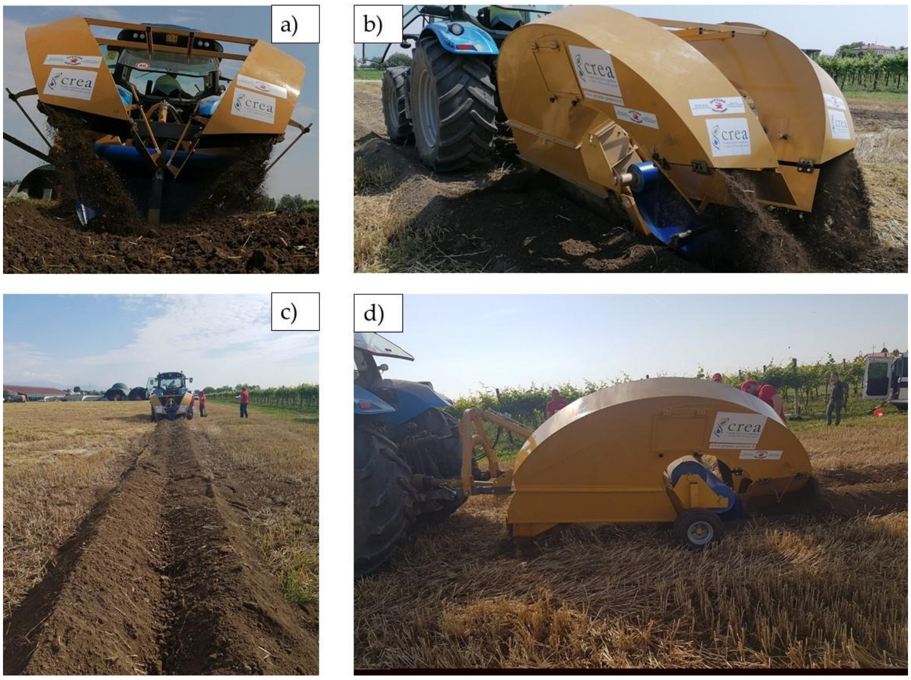


Figure 3 Rear view of the prototype. b) Prototype while working. c) Vision of the soil after the installation of the SWRS. d) Lateral view of the prototype.

The installed membrane was made up of polyethylene 630 gm m^{-2}, the dimension of the roll was 1.50 m width for 150.00 m length. Considering 1.50 m of width and 1.00 of ditch depth there are about 30 cm of soil profile without the presence of the impermeable membrane (Figure 4), therefore the farmer can normally keep on his own management of the field (ploughing, harrowing, etc…) without changing the management plan.

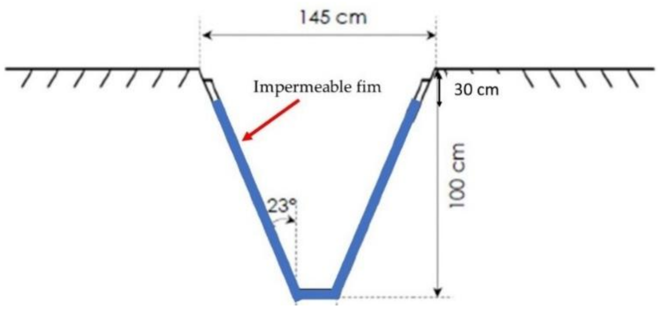


Figure 4 V-shaped profile of the soil and schematic representation of the SWRS membrane.

2 SWRS FIELD in collaboration with ITAP Fuentidueña de Tajo April 2023

2.1 Field description and SWRS installation

In April 2023, a SWRS was installed with CREA prototype on a plot divided into five with variations in plant density across two main groups. The first group consisted of three lines with a design supporting two rows of Guayule (AZ-2 accession) within the SWRS system at a density of 40,000 plants per hectare. The second group comprised two lines with a single row of guayule (AZ-2 accession) at a density of 20,000 plants per hectare. Planting, by hand, was completed in the autumn of 2023. No fertilization was applied.

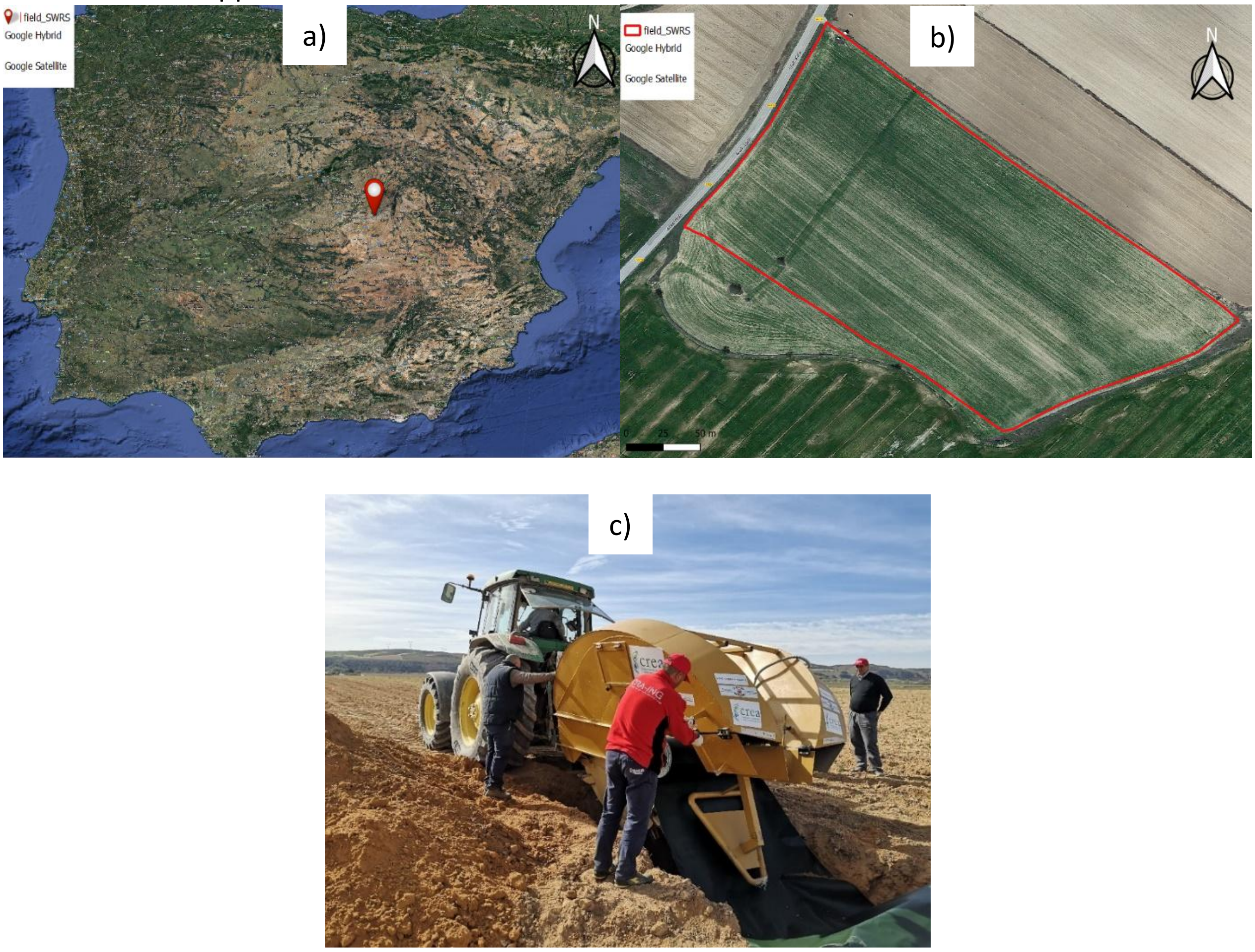


Figure 5 a-b) **Satellite view of the SWRS trial and c) prototype at work.**

Following this, sensors were installed at different depths and gradients relative to the SWRS system to continuously monitor soil moisture and temperature. The monitoring setup included sensors positioned at two depths (30 cm and 60 cm) within both high- and low-density plant groups, along with a high-precision rain gauge installed on-site to measure rainfall accurately.

To assess the SWRS's influence on water retention and temperature of the soil, Teros 11 sensors and the ZL6 datalogger were deployed, with complete sensor installation scheduled for February 2024 across twelve points within the experimental plot (Figure 6).

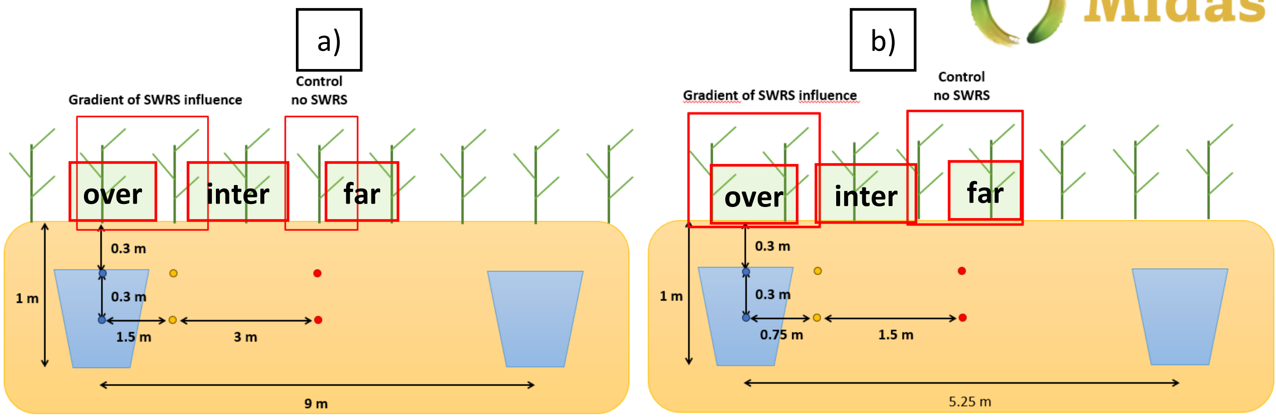


Figure 6. Experimental layout of sensors installation in a) First experimental design (2 lines), and b) Second experimental design (3 lines).

2.2 Sensors, data logger and drones

Teros 11 sensors are engineered to precisely measure volumetric soil moisture, electrical conductivity, and temperature, delivering high-quality continuous data under field conditions. These sensors operate on dielectric permittivity technology, which detects shifts in the soil's dielectric constant induced by variations in water content. Their precision and reliability in moisture measurement make them an essential tool for agronomic monitoring in areas influenced by the SWRS, allowing for an in-depth analysis of water retention efficiency across soil depths and its influence on guayule's water status. Additionally, drone-based remote sensing has been instrumental in monitoring the crop's health and the experimental plots. A DJI Mavic 3M drone equipped with RGB, and multispectral cameras was used for this purpose, enabling high-resolution image capture across different spectral bands. These images facilitate the analysis of critical vegetation parameters through the calculation of indices such as NDVI (Normalized Difference Vegetation Index). NDVI is a key indicator of plant health, measuring photosynthetic activity and biomass, and thus provides a visual assessment of plant vigor and stress across growth stages. Drone flights are strategically scheduled to align with critical phenological stages of guayule, generating comprehensive insights into crop responses to SWRS installation and fluctuating water availability.

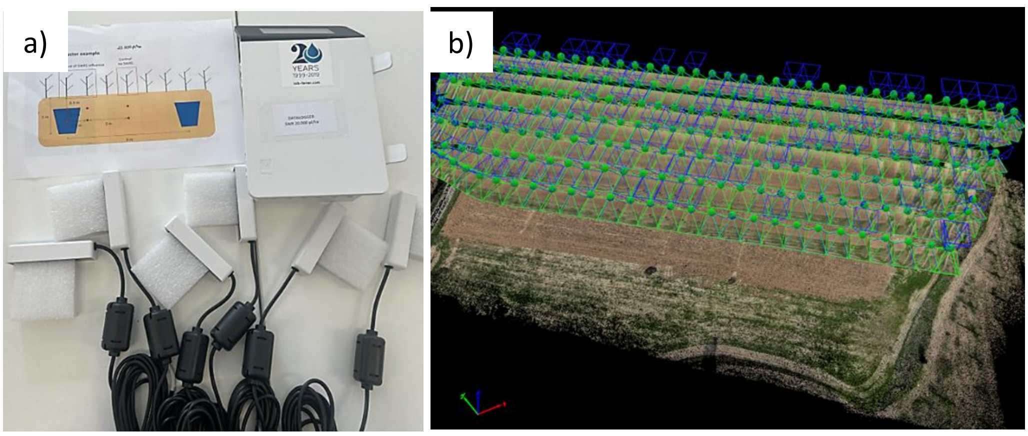


Figure 7 a) TEROS 11 sensors used in the test plot; b) Processing of the drone images in the trial plot.

This multifaceted experimental approach extends beyond evaluating the SWRS's efficacy as a water retention tool, focusing on integrating innovative agronomic practices that enhance input efficiency and strengthen the adaptive capacity of industrial crops against increasing water limitations imposed by climate change. Leveraging the comprehensive data provided by the Teros 11 sensors and the multispectral imaging capabilities of the DJI Mavic 3M drone, this project aims to establish a robust scientific basis supporting the adoption of sustainable agricultural technologies and the feasibility of scaling these practices across various arid regions in Europe.

2.3 Experimental Layout

The experimental design (Figure 8) introduces an expanded layout for evaluating the SWRS, focusing on increasing sensor coverage to assess water retention more accurately across multiple prototype lines

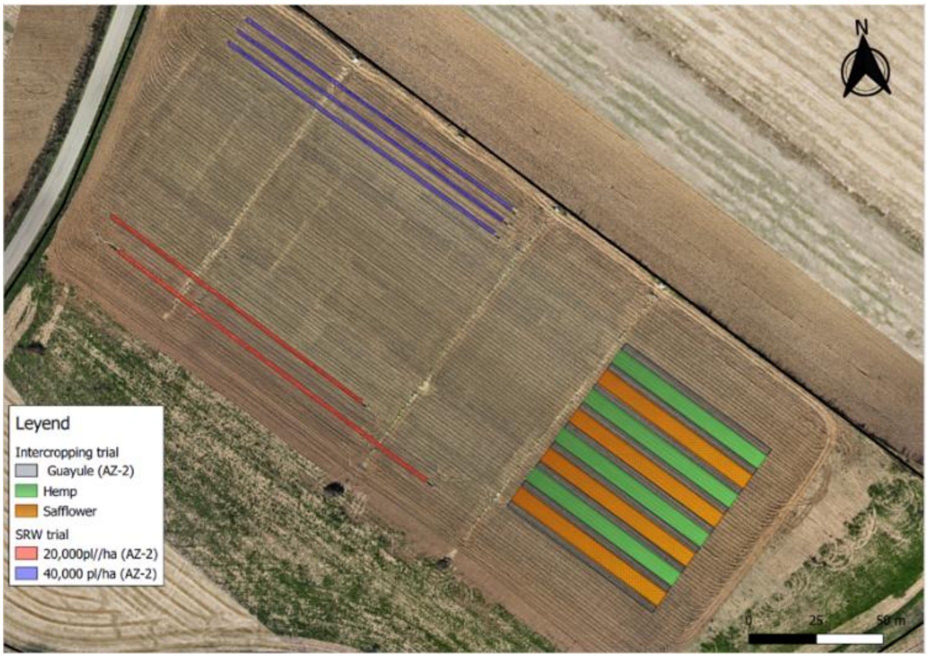


Figure 8. Design of SWR trial in the field.

First Experimental Design (2 red lines):

The first trial involves a basic configuration to evaluate SWRS effectiveness under a lower-density prototype layout.

Plot Dimensions: The experimental plot spans a length of 120 meters, providing a substantial test area for controlled observations with 3 repetitions. The **two SWRS prototype lines** are spaced 9 meters apart, allowing isolated observation of each SWRS line's effect on soil and guayule crop performance.

Guayule Line Distribution: In this design, guayule rows are spaced 1.5 meters apart, with one single row of plants within each SWRS prototype line. The spacing between plants is set at 0.33 meters, creating a planting framework that permits the evaluation of SWRS influence on soil moisture availability to guayule roots in a lower-density arrangement with reduced root competition.

Sensors: This layout includes three sensors total: two positioned in zones influenced by the SWRS (above the impermeable membrane, and intermediate sensor – 1.5 m apart) and one in an uninfluenced control zone (farther sensor – 4.5 m apart). Each sensor is installed at two depths (30 cm and 60 cm), resulting in six sensors across the plot. This configuration allows for detailed data collection on soil moisture across layers, providing precise insights into how the SWRS affects water retention at different soil depths.

Second Experimental Design (3 blue lines):

The second experimental design introduces a more intensive, expanded SWRS layout, enhancing system coverage and data collection through increased sensor density and a denser guayule planting arrangement.

Plot Dimensions: Similar to the first design, and 120 meters in length with 3 repetitions. However, in this trial, the SWRS prototype lines are spaced 3 meters apart, incorporating **three SWRS lines**

throughout the plot. This configuration allows for a more detailed analysis of SWRS water retention efficiency across closely spaced prototype lines.

Guayule Line Distribution: In this setup, the distance between guayule planting rows is reduced to 0.75 meters, with each SWRS prototype line containing two plant rows, creating a high-density planting arrangement. The spacing between plants remains at 0.33 meters. This layout aims to examine whether closer planting density, combined with SWRS, enhances water use efficiency by maximizing moisture retention and optimizing soil water distribution under conditions of higher root competition.

Sensors: Similar to the first design, this configuration uses three sensors in total: two positioned in zones directly influenced by SWRS (above the impermeable membrane, and intermediate sensor – 0.75 m apart) and one in a control zone without SWRS influence (farther sensor – 2.25 m apart). The sensors are also installed at two depths (30 cm and 60 cm), yielding a total of six sensors. This sensor layout allows for the monitoring of soil moisture profiles at multiple depths, facilitating comparisons of water retention effects under high-density planting and closer SWRS prototype spacing.

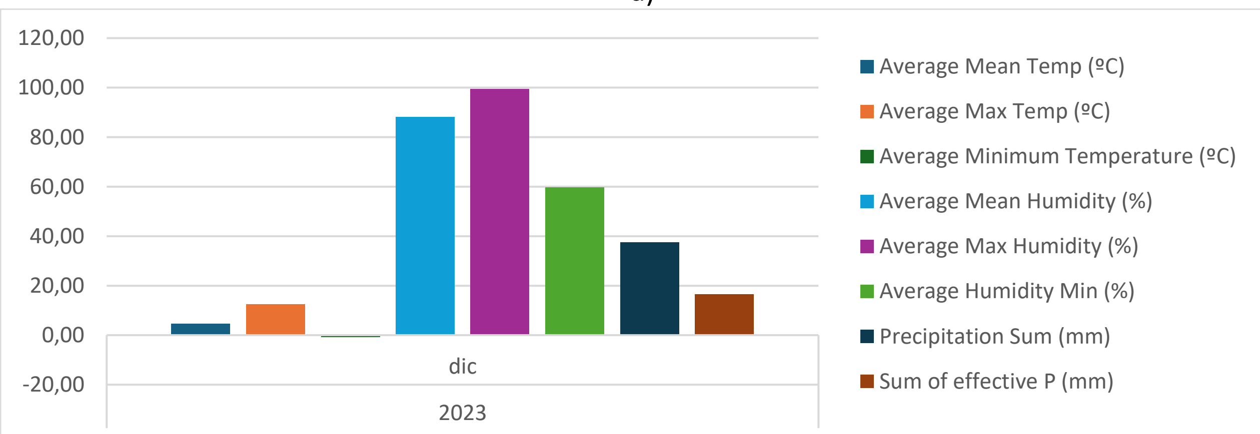
Both designs are intended to yield comprehensive and detailed datasets on SWRS efficacy for water retention in semi-arid soils. The sensor configurations within each design enable precise monitoring of soil moisture during the test period (12/01/2023 to 11/11/2024), which is crucial for assessing SWRS viability as a water management technology and its impact on guayule productivity and sustainability under water-limited conditions.

2.4 Preliminary results

Climatic data in the test region:

During the trial, the region was characterized by a typical Mediterranean or semi-arid climate. Monthly average temperature shows a typical pattern of seasonal variation: colder months in winter (January and February) with lower average temperatures, warmer months in summer (July and August) with higher average and maximum temperatures. Precipitation is highest in the winter and spring months (January and March) and decreases significantly during the summer

a)



b)

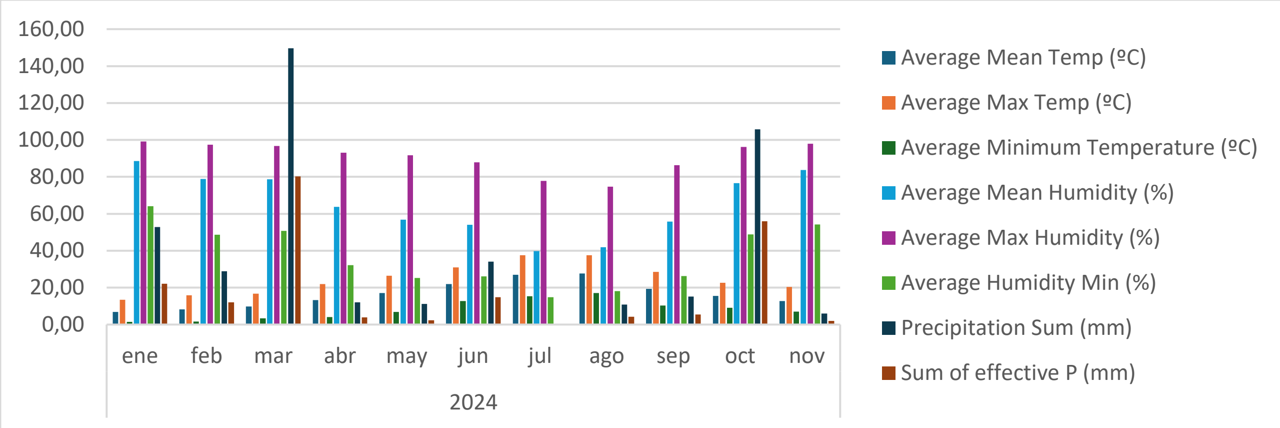


Figure 9. Climatic data during the trial, a) 2023 and b) 2024.

NDVI: The mean Normalized Difference Vegetation Index (NDVI) for the two SWRS experimental designs is presented in the following, allowing to evaluate the distribution and status of biomass in the guayule crop. The **average NDVI** is a statistical measure representing the mean NDVI values across a specified area. NDVI itself is an indicator used to measure the quantity, quality, and condition of biomass in a crop area, with values ranging from -1 to 1. Values closer to 1 indicate high vegetation density and photosynthetic activity, while values near 0 or negative indicate sparse or no vegetation. Calculating the average NDVI provides an overall view of vegetation health and coverage within a specific plot, averaging individual NDVI data points across the study area. In this experiment, the average NDVI for each SWRS design facilitates a comparative evaluation of biomass distribution and water retention effectiveness in enhancing guayule crop vigor. Thus, a higher and more uniform average NDVI in one design could indicate better water retention efficiency and a healthier vegetative response, whereas greater variability in average NDVI values could reflect differences in water availability or biomass structure.

First design (2 Lines): In the first experimental design, average NDVI values range from 0.23 to 0.33. The legend indicates that areas with lower biomass (0.23 - 0.25) are represented in darker tones (red), while areas with higher biomass (0.28 - 0.33) appear in lighter tones (blue). This gradient suggests variability in vegetation density within the plot, possibly related to the SWRS line arrangement and the soil's water retention capacity. The third repetition of the lines shows increased biomass, with values between 0.27 and 0.28; however, definitive conclusions cannot yet be drawn due to the vegetative growth stage of the guayule plants.

Second design (3 Lines): In the second design, the same average NDVI information is observed, with identical value ranges (0.23 - 0.33). This design includes a higher planting density and a closer SWRS arrangement. NDVI values appear more uniformly distributed within the upper ranges, which could indicate improved water retention efficiency and soil water availability, supporting higher vegetation density compared to the first design.

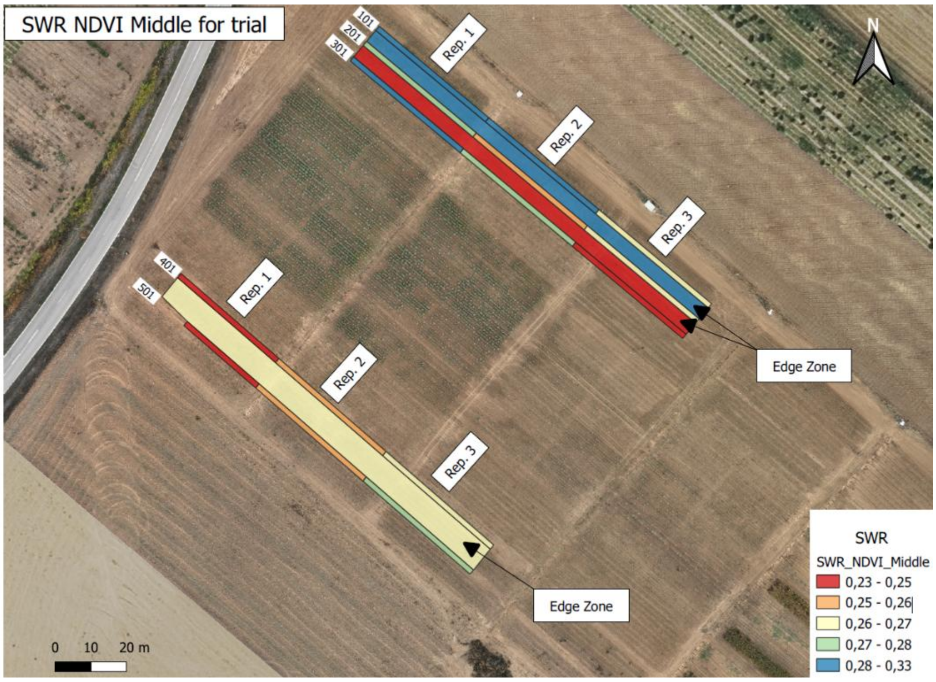


Figure 10. Mean NDVI in the SWR trial design sections

For the statistical analysis of the data obtained from the Subsurface Water Retention System (SWRS) trials, **SPSS** (Statistical Package for the Social Sciences) software was used.

SPSS is widely employed in agronomic research due to its capability to perform advanced correlation analyses and multiple comparison tests. In this study, two main types of analysis were conducted:

Pearson correlation:

This analysis evaluated the linear relationship between variables, such as the distance to the SWRS and the soil's humidity and temperature values. Pearson correlation allowed us to determine whether there was a significant dependency between these variables, showing how proximity to the SWRS affects soil conditions. In this case, a negative and significant correlation between distance and humidity indicated that sensors closer to the SWRS impermeable membrane recorded higher humidity levels, validating the system's effectiveness in retaining water in marginal areas.

Duncan's multiple range test:

To identify significant differences between sensor readings at different depths and distances from the SWRS, Duncan's test was used. This test allows for the comparison of multiple means and classifies data into homogeneous subsets. This method facilitates detecting specific patterns in the data, such as variation in humidity and temperature according to the proximity to the SWRS system and soil depth. The results of Duncan's test showed significant differences between sensors, indicating that water retention is greater in areas under impermeable membrane and at greater depths, contributing to a more detailed understanding of SWRS effectiveness under various experimental conditions. Using SPSS made it possible to process and organize complex data, facilitating a precise and structured interpretation of the results, which is essential for validating the impact of SWRS on water retention in semi-arid soils and its potential to improve water sustainability in guayule cultivation.

Temperature and moisture content data evaluation:

Table 1. Average humidity and temperature measurements detected by the different sensors.

Treatment Low density (First trial, 2 lines)						
	Sensor					
	Over		Intermediate		Far	
	30 (cm)	60 (cm)	30 (cm)	60 (cm)	30 (cm)	60 (cm)
HUMIDITY (%)	0.22	0.25	0.25	0.21	0.23	0.17
TEMPERATURE (°C)	14.99	14.30	14.70	14.40	14.85	14.32

Treatment High density (Second trial, 3 lines)						
	Sensor					
	Over		Intermediate		Far	
	30 (cm)	60 (cm)	30 (cm)	60 (cm)	30 (cm)	60 (cm)
HUMIDITY (%)	0.25	0.26	0.26	0.25	0.24	0.24
TEMPERATURE (°C)	17.13	16.85	16.69	16.77	16.45	16.86

First trial (2 lines):

Following Pearson's correlation analysis on the temperature data collected from sensors at different distances (blue: above impermeable membrane; yellow: outside but influenced by the impermeable membrane; red: farther from the impermeable membrane), the results were as follows: The Pearson correlation coefficient between temperature and distance is -0.006, which is practically zero. This indicates no significant linear relationship between temperature and distance; that is, changes in distance do not consistently affect temperature in this case. In summary, the placement distance of the sensors does not significantly influence temperature.

Humidity and distance data evaluation:

After analyzing Pearson's correlation in the humidity data collected from the sensors at various distances, the results showed a Pearson correlation coefficient of -0.256, indicating a negative correlation between humidity and distance. This suggests that as distance increases, humidity tends to decrease. The p-value is 0.0001, below the common threshold of 0.05, indicating that this correlation is statistically significant. Given the negative correlation and its significance, we conclude that as sensors move further away, humidity consistently and significantly decreases. This suggests that proximity to the SWRS system has a real impact on moisture retention, benefiting the nearest areas. In summary, distance significantly and negatively influences humidity, which decreases as distance increases.

Temperature differences by distance and depth:

At a depth of 30 cm, the temperature is significantly higher over the impermeable membrane (blue) compared to the intermediate point (yellow), while the distant point (red) shows no significant differences with either of the other points.

At a depth of 60 cm, temperature does not vary significantly by distance.

Humidity differences by distance and depth:

At a depth of 30 cm, humidity differs significantly based on the distance of the sensors. Humidity measured at the intermediate point (yellow) is significantly higher than at the other two distances. Humidity at the distant point (red) is also significantly higher than the humidity recorded over the impermeable membrane (blue).

At a depth of 60 cm, humidity shows significant differences according to the distance of the sensors. Humidity measured over the impermeable membrane (blue) is significantly higher than at the other two distances. Humidity at the intermediate point (yellow) is also significantly higher than the humidity recorded at the distant point (red).
This indicates a definite pattern of moisture retention in which the SWRS maintains the highest moisture levels in the areas closest to the impermeable membrane, with a gradual decrease as distance increases.
This result confirms that at a depth of 60 cm, SWRS is effective in preserving higher amounts of moisture near the impermeable membrane, which is favorable for improving water availability in the soil.

Second trial (3 lines):
Temperature and distance data evaluation:
Following Pearson's correlation analysis on the temperature data collected from sensors at different distances (blue: above impermeable membrane; yellow: outside but influenced by the impermeable membrane; red: farther from the impermeable membrane), the results were as follows:
The Pearson correlation coefficient between temperature and distance is -0.022, which is practically zero. This indicates no significant linear relationship between temperature and distance; that is, changes in distance do not consistently affect temperature in this case. In summary, the placement distance of the sensors does not significantly influence temperature.

Humidity and distance data evaluation:
After analyzing Pearson's correlation in the humidity data collected from the sensors at various distances, the results showed a Pearson correlation coefficient of -0.203, indicating a negative correlation between humidity and distance. This suggests that as distance increases, humidity tends to decrease. The p-value is 0.000, below the common threshold of 0.05, indicating that this correlation is statistically significant. Given the negative correlation and its significance, we conclude that as sensors move further away, humidity consistently and significantly decreases. This suggests that proximity to the SWRS system has a real impact on moisture retention, benefiting the nearest areas. In summary, distance significantly and negatively influences humidity, which decreases as distance increases.
Temperature differences by distance and depth:
At a depth of 30 cm, temperature varies significantly with distance. Specifically, the temperature recorded above the impermeable membrane (blue) is considerably higher than the measurements at the intermediate point (yellow) and the distant point (red), which, in turn, do not show significant differences between each other.
At a depth of 60 cm, temperature does not show significant differences based on distance.

Humidity differences by distance and depth:
At a depth of 30 cm, humidity varies significantly with distance, with the highest value recorded by the blue sensor located above the impermeable membrane.
At a depth of 60 cm, humidity also varies significantly with distance. In this case, the humidity recorded above the impermeable membrane (blue) is considerably higher than at the other two points. Additionally, the humidity at the intermediate point (yellow) is significantly higher than the humidity recorded at the distant point (red).
This indicates a clear pattern of moisture retention in which the SWRS maintains the highest moisture levels in areas closest to impermeable membrane, with a gradual decrease as distance increases.

This result confirms that at a depth of 60 cm, the SWRS is effective in preserving higher amounts of moisture near the impermeable membrane, which is beneficial for improving water availability in the soil.

2.5 Conclusion

This study demonstrates the effectiveness of the Subsurface Water Retention System (SWRS) in retaining soil moisture, especially in the areas closest to the impermeable membrane and at a depth of 60 cm. The data obtained permits the conclusion that the SWRS significantly optimizes the availability of water in the soil. The results show that the points located directly above the impermeable membrane (designated as blue) have considerably higher moisture than the intermediate (yellow) and distant (red) points. This trend is observed at both 30 cm and 60 cm depth, with a more pronounced effect in the deeper layer, indicating that the SWRS promotes greater water retention in areas closer to the system.

On the other hand, the analysis of temperature shows that, although there are variations in the points near the SWRS, these differences are not as marked or consistent as in the case of humidity. This suggests that the impact of the system is greater on water retention than on soil temperature variation.

3 SWRS field in collaboration with UNICT Ispica 19-22 April 2023

3.1 Materials and methods

The trial conducted by UNICT in Ispica (36° 42' 43.6"N 14° 57' 31.3"E) assesses the response of castor (*Ricinus communis* L.), sorghum (*Sorghum bicolor* (L.) Moench) and hemp (*Cannabis sativa* L.) in a sandy soil affected by poor water retention capacity under rainfed condition and non-limiting soil water availability.

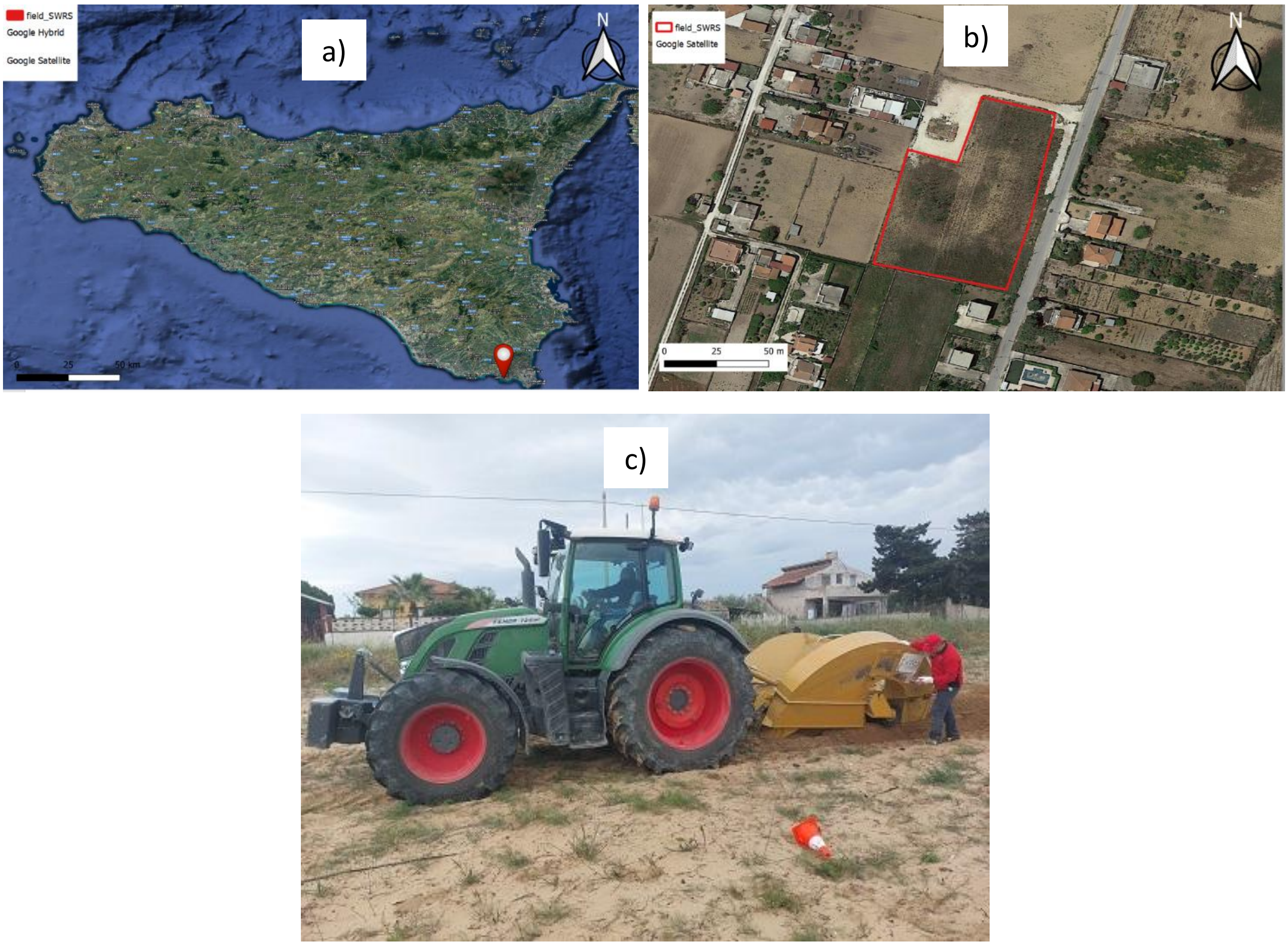


Figure 11 a-b)View from satellite of the field and c) prototype at work.

The SWRS consists of impermeable plastic strips, 1.2 m wide and 9 m apart, placed 1 m below ground level. The strips were placed on 20/04/2023.

The experimental design is a split plot design with irrigation as the main factor assigned to the main plots (24.5 m x 51 m, each main plot contains 3 SWRS strips) and crop as the subfactor assigned to the subplots (24.5 m x 51 m).

Irrigation factor

The irrigation factor has 2 levels: 0 and 100% of maximum crop evapotranspiration (ETm) restoration).

Irrigation is provided by a drip irrigation system providing 100% of maximum crop evapotranspiration (ETm) restoration. Daily ETm is calculated according to:

$$ETm = ET0 \times Kc$$

where ETm is the maximum daily evapotranspiration (mm) and Kc is the crop coefficients (Kc) according to (Allen et al., 1998, p. 56).

Crop factor

The crop factor has 3 categories: castor variety C1012, sorghum variety Sweet Betty and hemp variety Futura 83.

The sowing took place after tilling the soil with a subsoiler on 30/04/2024 using a manual single-row seeder (Terradonis) at 3.3 m-2, 11 m^{-2} and 125 m^{-2} germinable seeds density for castor, sorghum and hemp respectively.

Measurements

Soil water content has been measured every ten days at 30 and 50 cm depth and distances of 0, 1.5 and 4.5 m from the SWRS strips using soil moisture sensors that measure apparent dielectric permittivity (Teros 10, Meter).

LAI has been measured monthly during the growing season (May – September), at three distances from the SWRS strips (0 m, 1.5 m and 4.5 m) using an AccuPAR model LP-80 PAR/LAI Ceptometer, which calculates by measuring the amount of radiation transmitted through the canopy and of radiation scattered by leaves within the canopy and comparing with the above canopy photosynthetically active radiation (Decagon Devices, Inc.).

The normalized difference vegetation index (NDVI) has been calculated on the bases of drone images at red (650 nm) and near-infrared (860 nm) wave lengths taken monthly during the growing season (May – September).

The total aboveground biomass has been harvested at the end of the growing cycle (31 October for hemp and 14 November for castor and sorghum) from 1 m^2 plots at three distances from the SWRS strips (0 m, 1.5 m and 4.5 m) for each SWRS strip (3 replicates). The seeds have been separated manually from the biomass to determine the seed yield.

Figure 12 Placement of the Teros 10 soil moisture sensor

Fig 13. Layout of the soil moisture sensors and irrigation system.

3.2 Results

The amount of rain after the sowing date was not enough for the establishment of the plant in the rainfed plots for all the crop examined.

LAI was significantly affected by the distance from the SWRS under irrigated conditions only for hemp (Fig. 15). Sorghum reached the highest values of LAI.

Both aboveground biomass and seed yield of hemp were higher in the positions closer to the SWRS system (Fig. 15 and 16).

Sorghum and castor AGB and seed yield measurements are ongoing.

Fig 13. Emergence of the hemp plot.

Fig14. Sorghum, hemp and castor plants after 3 weeks from sowing.

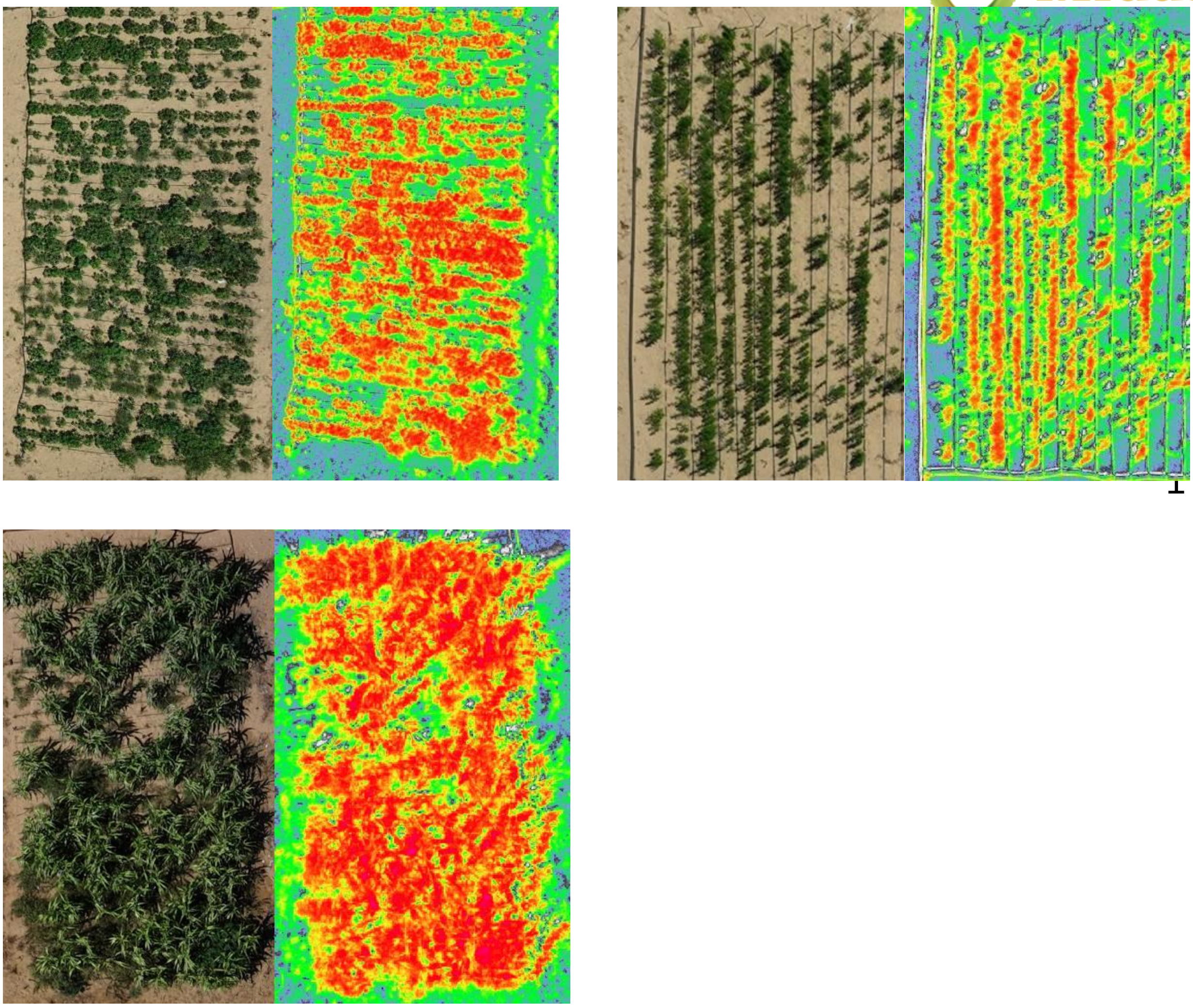


Fig 5 Visible and NDVI images of castor (a, b), hemp (c, d) and sorghum (e, f) of the irrigated plots on 1st of July.

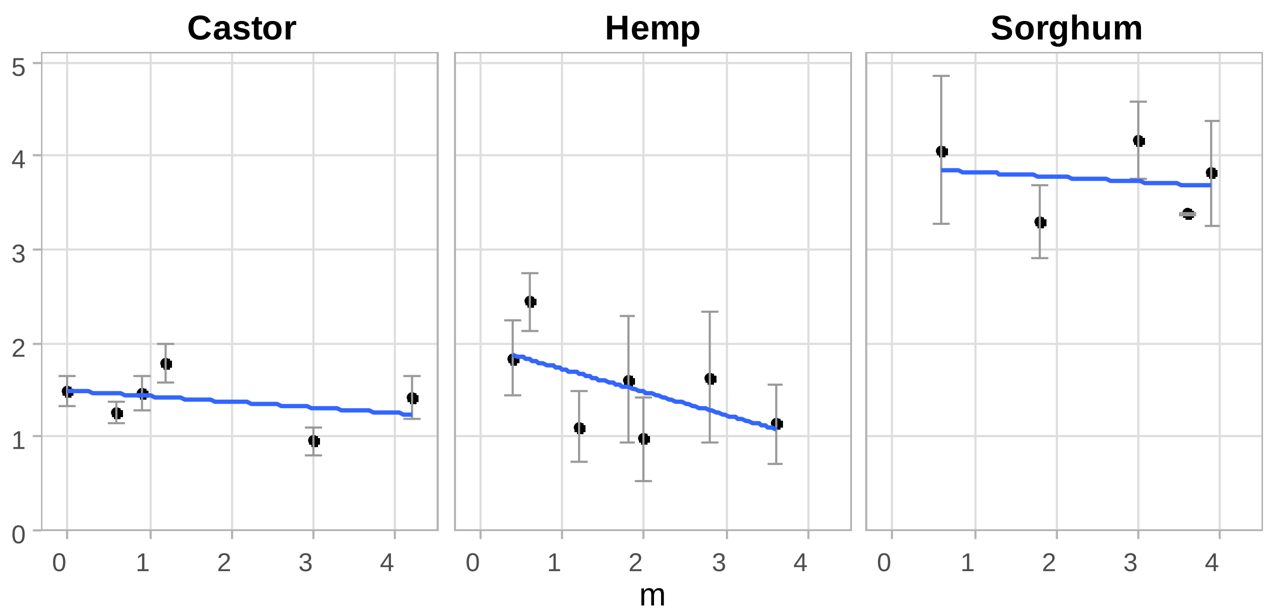


Fig15. Leaf area index (LAI) in relation with distance from the SWRS under non-limiting water availability.

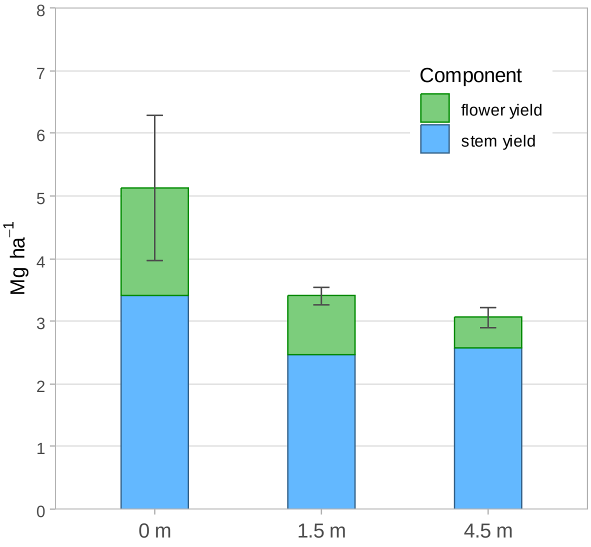


Fig 16. Total aboveground biomass yield and components (flowers and stem) of hemp.

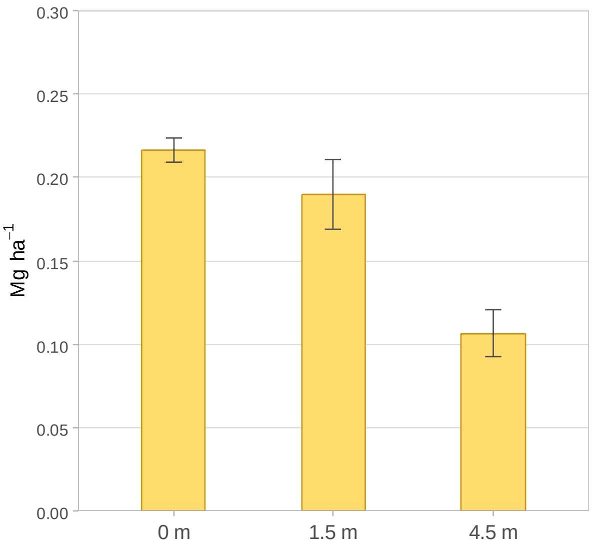


Fig 17. Seed of hemp.

3.3 Conclusions

The SWRS had low influence on NDVI values and LAI under non-limiting water availability. More pronounced effects are expected under limiting water conditions, for which no preliminary data are available due to a severe drought.

4 Reference

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